CLAIMS

What I claim is:

1. A liner system for resisting the abrasive forces of a slurry being supplied to the upper end of a materials classifying cyclone comprising:

a) a cyclone inlet housing including a head section and a feed duct for supplying the slurry to the head section; and

b) at least a pair of head section abrasion resistant liners arranged in an end-to-end relationship with each other at the interior surface of the head section of said inlet housing;

2. A liner system as claimed in claim 1 and further comprising: a feed duct liner of abrasion resistant material in the feed duct of said inlet housing.

3. A liner system as claimed in claim 2 wherein each of said head section liners and said feed duct liner comprises:

a) rigid substrate; and

b) an abrasion resistant material bonded to the inwardly facing surface of each of said rigid substrates.

4. A liner system as claimed in claim 3 and further comprising at least one attachment means for demountably holding said head section liners in contiguous engagement with the inner wall of the head section of said inlet housing and at least one attachment means for demountably holding said feed duct liner in contiguous engagement with the bottom and side walls of the feed duct of said inlet housing..

5. A liner system as claimed in claim 4 wherein each of said attachment means comprises:

a) a threaded fastener on the inwardly facing surface of one of said rigid substrates;

b) a bolt extending from the outer surface of said inlet housing into threaded engagement with said threaded fastener.

6. A liner system as claimed in claim 5 wherein each of said attachment means further comprises;

a) said threaded fastener being buried within said abrasion resistant material;

b) said bolt having an inner end buried within said abrasion resistant material; and

c) said bolt having an axial bore formed therethrough so that when said abrasion resistant material wears down and the inner end of said bolt is exposed a small amount of the slurry

being processed in the cyclone will seep out to indicate that a liner replacement operation should be scheduled.

7. A liner system as claimed in claim 3 wherein said abrasion resistant material is an elastomer.

8. A liner system as claimed in claim 2 wherein said rigid substrate is metal.

9. A liner system as claimed in claim 2 and further comprising:

a) the head section and the feed duct of said inlet housing having open tops;

b) said feed duct liner being of upwardly open U-shape in-cross-section;

c) a cover plate demountably mounted atop said inlet housing for closing the open tops of the head section and the feed duct of said inlet housing; and

d) an abrasion resistant cover plate liner in contiguous engagement with the downwardly facing surface of said cover plate.

10. A mechanism for removing abrasion resistant cones from the lower end of a materials classifying cyclone through the opened top of an inlet housing thereof, said mechanism comprising:

a) a truncated conical housing depending from the inlet housing of said cyclone for receiving the materials to be classified therefrom and having an open apex at its lower end;

b) a ring-shaped shelf at lower end of said conical housing and extending into the open apex thereof;

c) a lifting ring resting on said ring-shaped shelf;

d) a pair of hoisting straps attached to diametrically opposed sides of said lifting ring and extending upwardly through said conical housing;

e) a frusto-conical apex cone having a downwardly tapering body with an annular flange circumscribing its upper end, the annular flange of said apex cone resting on said ring with its body depending through the open apex of said conical housing;

f) at least two frusto-conical abrasion resistant cones in said conical housing in a stacked array atop the annular flange of said apex cone; and

g) means on the upper ends of said hoisting straps for attachment to a lifting apparatus for moving said lifting ring, said apex cone and said array of cones out of said conical housing and out of said cyclone through the opened top of the inlet housing thereof.

11. A mechanism as claimed in claim 10 wherein said frusto-conical abrasion resistant cones comprise:

a) upper and middle cones each having a rigid substrate with an abrasion resistant liner bonded to the inner surface of the substrate; and

b) a lower cone having a rigid substrate with an abrasion resistant liner bonded to the inner surface of the substrate.

12. A mechanism as claimed in claim 11 wherein the substrate of said upper and middle cones are formed of metal and the abrasion resistant liners of said upper and middle cones is an elastomer.

13. A mechanism as claimed in claim 11 wherein the substrate of said lower cone is formed of a rigid urethane and the abrasion resistant liner of said lower cone is ceramic, said abrasion resistant ceramic liner having a top surface.

14. A mechanism as claimed in claim 13 wherein the top surface of said abrasion resistant ceramic liner of said lower cone is curved along the inner edge of its top surface for reducing turbulence in the material being classified as it flows past the joint between said lower cone and said middle cone stacked thereon.

15. A mechanism as claimed in claim 10 wherein said apex cone comprises:

a) a rigid substrate; and

b) an abrasion resistant material bonded to the inwardly facing surface of said substrate.

16. A mechanism as claimed in claim 15 wherein said substrate is formed of rigid urethane and said abrasion resistant material is ceramic.

17. A mechanism as claimed in claim 10 and further comprising:

a) said frusto-conical abrasion resistant cones each having a groove formed in its upper edge; and

b) an O-ring in each of the grooves of said cones for sealing the joints between the stacked array thereof.

18. A cyclone having an in-situ abrasive resistant liner removal system comprising in combination;

a) an inlet housing including a head section and a feed duct for supplying materials to be classified to the head section, the head section having an open bottom end;

b) a cover plate mounted atop said inlet housing and movable for opening the top of said inlet housing;

c) a truncated conical housing depending from the open bottom end of the head section of said inlet housing and having an open apex at its lower end;

d) a ring-shaped shelf at lower end of said conical housing and extending into the open apex thereof;

e) a lifting ring resting on said ring-shaped shelf;

f) a pair of hoisting straps attached to diametrically opposed sides of said lifting ring and extending upwardly through said conical housing;

g) a frusto-conical apex cone having a downwardly tapering body with an annular flange circumscribing its upper end, the annular flange of said apex cone resting on said lifting ring with its body depending through the lower end of said conical housing;

h) at least two frusto-conical abrasion resistant cones in said conical housing in an axially stacked array atop the annular flange of said apex cone;

i) an abrasion resistant feed duct liner in the feed duct of said inlet housing and removable through the open top of said inlet housing when said cover plate is moved to open the top of said inlet housing;

j) at least two abrasion resistant head section liners arranged in an end-to-end relationship about the inner surface of the head section of said inlet housing and removable through the open top of said inlet housing when said cover plate is moved to open the top of said inlet housing; and

k) means on the upper ends of said hoisting straps for attachment to a lifting mechanism for moving said lifting ring, said apex cone and said stacked array of frusto-conical abrasion resistant cones out of the cyclone when said cover plate is moved to open the upper end of said inlet housing.

19. The combination of claim 18 wherein said feed duct liner is of U-shape in cross-section to line the bottom and sidewalls of said feed duct.

20. The combination of claim 18 wherein the head section of said inlet housing is of cylindrical configuration and each of said head section liners are of arcuate configuration to line the inner wall of the head section of said inlet housing.

21. The combination of claim 18 and further comprising:

a) said frusto-conical abrasion resistant cones each having a groove formed in its upper edge; and

b) an O-ring in each of the grooves of said cones for sealing the joints between each of the stacked array of said cones and between the uppermost one of said cones and said head section liners.

22. The combination of claim 18 wherein said apex cone comprises:

a) a rigid substrate having an annular groove formed in the peripheral surface proximate the lower end thereof; and

b) a liner of abrasive resistant material bonded to the inside of said substrate.

23. The combination of claim 22 and further comprising a splash skirt demountably attached to the lower end of said substrate of said apex cone.

24. The combination of claim 23 wherein said splash skirt is an elastomeric tubular structure with an inwardly extending flange at its upper end, said splash skirt being removably snapped in-place within the annular grooved formed at the lower end of said substrate of said apex cone, said splash skirt having an inwardly extending flange at its lower end with a liner of elastomeric material removably snapped in-place within said splash skirt.

25. The combination of claim 18 and further comprising:

a) a vortex finder depending from said cover plate into the head section of said inlet housing, said vortex finder including,

i) a rigid substrate of tubular configuration;

ii) an abrasion resistant ceramic liner bonded to the exterior of said substrate; and

iii) an abrasion resistant ceramic liner bonded to the interior of said substrate.

26. The combination of claim 18 wherein said feed duct liner and said head section liners each comprise:

a) rigid substrate; and

b) an abrasion resistant material bonded to the inwardly facing surface of said substrates.

27. The combination of claim 26 and further comprising attachment means for demountably holding said head section liners in contiguous engagement with the inner wall of the head section of said inlet housing and demountably holding said feed duct liner in contiguous engagement with the bottom and side walls of the feed duct of said inlet housing with there being at least one of said attachment means for each of said head section liners and at least one of said attachment means for said feed duct liner.

28. The combination of claim 27 wherein each of said attachment means comprises:

a) a threaded fastener on the inwardly facing surface of one of said substrates; and

b) a bolt extending from the outer surface of said inlet housing into threaded engagement with said threaded fastener.

29. The combination of claim 28 wherein each of said attachment means further comprises;

a) said threaded fastener being buried within said abrasion resistant material;

b) said bolt having an inner end which is buried within said abrasion resistant material; and

c) said bolt having an axial bore formed therethrough so that when said abrasion resistant material wears down and the

inner end of said bolt is exposed, the slurry being processed in the cyclone will seep out to indicate that a liner replacement operation should be scheduled.

30. A cyclone as claimed in claim 18 and further comprising:

a) a plurality of clamping means mounted at spaced apart locations about said inlet housing for movement between a cover plate engaged position wherein said cover plate closes the top of said inlet housing to a cover plate disengaged position wherein said cover plate is movable to open the top of said inlet housing; and

b) hinge means connected to said inlet housing and to said cover plate for movement of said cover plate between the inlet housing opening and closing positions.

31. A cyclone having an in-situ abrasive resistant liner removal system comprising in combination;

a) an inlet housing having an open bottom end;

b) a cover plate mounted atop said inlet housing and movable for opening the top thereof;

c) a truncated conical housing depending from the open bottom end of said inlet housing and having an open apex at its lower end; said conical housing including,

i) a ring-shaped flange attached to the open bottom end of said inlet housing,

ii) a sleeve defining the open apex of said conical housing,

iii) a ring-shaped shelf at the lower end of said sleeve and extending into the open apex thereof, and

iii) a plurality of struts having upper ends attached to said ring-shaped flange and lower ends attached to said sleeve, said struts being spaced apart relative to each other to provide said conical housing with a plurality of side openings;

d) a lifting ring resting on said ring-shaped shelf;

e) a pair of hoisting straps attached to diametrically opposed sides of said lifting ring and extending upwardly through said conical housing;

f) a frusto-conical apex cone having a downwardly tapering

body with an annular flange circumscribing its upper end, the annular flange of said apex cone resting on said lifting ring with its body depending axially through the open apex of said conical housing;

g) at least two frusto-conical abrasion resistant cones in said conical housing, said cones arranged in an axially stacked array atop the annular flange of said apex cone; and

h) means on the upper ends of said hoisting straps for attachment to a lifting mechanism for moving said lifting ring, said apex cone and said stacked array of cones out of the cyclone when said cover plate is moved to open the upper end of said inlet housing.

32. A cyclone as claimed in claim 31 and further comprising a plurality of swing bolts mounted at spaced apart locations on said ring shaped flange of said conical housing for movement between a cover plate engaged position wherein said cover plate and said conical housing are in a clamped position on said inlet housing and a cover plate disengaged position for releasing the clamped positioning of said cover plate and said conical housing on said inlet housing.

33. A materials classifying cyclone having an inlet housing and a downwardly tapering truncated conical housing, said cyclone comprising:

a) a frusto-conical lower cone mounted in the conical housing of said cyclone, said lower cone and having a substrate with an abrasion resistant liner bonded to the inner surface of the substrate, said lower cone having a top surface;

b) a frusto-conical upper cone axially stacked on said lower cone and having a substrate with an abrasion resistant liner bonded to the inner surface thereof;

c) said abrasion resistant liner of said lower cone having a relatively long resistance to wear in comparison to the resistance to wear of the abrasion resistant liner of said upper cone; and

d) said lower cone having a curved surface formed on the inner edge of the top surface thereof to reduce turbulence produced in said cyclone when the thickness of the liner of said upper cone wears to a thickness which is less than the thickness of the liner of said lower cone.

34. The cyclone of claim 33 wherein the abrasion resistant liner of said lower cone is ceramic and the abrasion resistant liner of said upper cone is an elastomer.

35. A method for in-situ removal of abrasion resistant liners from a cyclone comprising the steps of:

a) disconnecting at least a discharge duct from a nozzle of a vortex finder of said cyclone;

b) opening the top of an inlet housing of said cyclone by moving a cover plate and removing a cover plate liner; and

c) moving at least a pair of cone liners and an apex cone axially out of a conical housing of said cyclone and through the open top of said inlet housing by raising a pair of hoisting straps that are connected to a lifting ring upon which said cone liners and said apex cone are supported in a stacked array.

36. The method of claim 35 including the further step of removing a feed duct liner and at least a pair of head section liners from said inlet housing through the open top of said inlet housing of said cyclone.

37. The method of claim 36 including the further step of undoing a plurality of attaching means which hold said feed duct liner and said head section liners in said inlet housing prior to the step of removing said feed duct liner and said head section liners from said inlet housing of said cyclone.

38. The method of claim 35 including the further steps of:

a) interrupting the moving of step c) when a first one of said stacked array of said cone liners and said apex cone clears the open top of said inlet housing to allow removal of said first one from said stacked array;

b) resuming the movement of step c) when said first one of said stacked array has been removed; and

c) repeating the steps of interrupting and resuming each time one of said stacked array of said cone liners and said apex cone clears the open top of said inlet housing.

39. The method of claim 35 including the further steps of:

a) forming a group of least two cone liners and an apex cone, said group including any of the removed cone liners and apex cone which are reusable and any replacements for the ones which are worn out;

b) arranging the formed group of said cone liners and said apex cone in a reverse order stacked array on said lifting ring; and

c) moving said reverse order stacked array of said cone liners and said apex cone through the open top of said inlet housing and axially into said conical housing by lowering said hoisting straps and said lifting ring into said cyclone.

40. The method of claim 37 including the further steps of:

a) installing said removed feed duct liner and said head section liners in said inlet housing if they are reusable and any replacements for the ones which are worn out;

d) closing the top of said inlet housing by installing the removed cover plate liner if it is reusable or a replacement if it is worn out and replacing the cover plate; and

e) reconnecting said discharge duct to said nozzle of said vortex finder.

41. The method of claim 40 including the further step of resecuring said plurality of attaching means to hold said installed feed duct liner and head section liners in said inlet housing.

42. The method of claim 39 including the further steps of:

a) interrupting the moving of step c) when said apex cone of said stacked array has moved into said inlet housing to allow placement of a first one of said cone liners on said apex cone;

b) resuming the movement of step c) when said first one of said cone liners has been placed on said apex cone; and

c) repeating the steps of interrupting and resuming the movement of step c) each time a subsequently placed one of said cone liners of said stacked array moves into said inlet housing.